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CRISIS EVENTS FOR PALEOGENE MOLLUSCAN FAUNAS IN THE SOUTHEASTERN UNITED STATES

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ABSTRACT

Range and distribution data on 555 Oligocene and 2979 Paleocene and Eocene molluscan species in the southeastern United States show major faunal turn-overs (extinctions and originations) at group boundaries. These faunal turn-overs suggest multiple crisis events associated with marine regressive and transgressive events. The most significant of these events occurred at the Eocene-Oligocene boundary, where several prominent and long ranging Paleocene-Eocene genera became extinct.

INTRODUCTION

The Paleogene sequence of the southeastern United States contains one of the best preserved and most diverse Paleogene marine invertebrate faunal assemblages known to science. It is possibly surpassed in its diversity only by the Paleogene marine assemblages of the Paris Basin in France. Almost 500 molluscan species (including subspecies, varieties, and unnamed forms) have been reported from the Gosport Sand (Middle Eocene) in Alabama alone. Although impressive, this number is dwarfed by the 773 molluscan species reported by Dolin, Dolin, and Le Renard (1980) from a single Auversian (Bartonian - Middle Eocene) locality in the Paris Basin at Baron, France. The stratigraphic groups of the southeastern United States' Paleogene sequence are roughly equivalent to the European stages as follows: (1) Midway Group = Thanetian (Paleocene), (2) Wilcox Group = Sparnacian and Cuisian (Lower Eocene), (3) Claiborne Group = Lutetian (Middle Eocene), (4) Jackson Group = Bartonian and Priabonian (Middle and Upper Eocene), and (5) Vicksburg Group = Stampian (Lower Oligocene). The division of both the southeastern United States and Paris Basin Paleogene sequences is primarily based on: (1) depositional cycles associated with transgressive and regressive marine events and (2) on the faunal similarities of the component marine units.

The highly diverse molluscan faunas of the Paleogene provide sensitive indicators to changes in

marine environments. For this reason, they are particularly important to studies concerning early Tertiary climatic trends. The distribution of Paleogene molluscan species in the southeastern United States is given for the large part in the catalogue of Palmer and Brann (1965, 1966) on the Paleocene and Eocene Mollusca and in the recent works of Dockery (1982) and MacNeil and Dockery (1984) on the Lower Oligocene Mollusca of the Vicksburg Group. The catalogue of Palmer and Brann is of particular value as: (1) it summarizes a large volume of literature on over 2800 species, (2) it updates the generic placement of species, and (3) the senior author was a systematist familiar with the faunas. This catalogue is updated here by the work of Toulmin (1977), Dockery (1977, 1980) and by several papers in *Tulane Studies in Geology and Paleontology* and in *Mississippi Geology* to include data on 2979 Paleocene and Eocene molluscan species (including subspecies, varieties, and unnamed forms). The works of Dockery (1982) and MacNeil and Dockery (1984) provide data on an additional 555 species. Oligocene Mollusca from the residual chert of the Flint River Formation in Georgia are not included in these data as this chert is a residue derived from weathered carbonates of several geologic horizons.

A summary of the Paris Basin Paleocene and Eocene Mollusca of France is given in the *Iconographie Complete des Coquilles Fossiles de l'Eocene des Environs de Paris* by Cossmann and Pissarro (1904-1913). This monumental work includes over 3500 molluscan species, which are illustrated in a series of 110 plates. Though this work is not updated, its data on species distributions is useful for a general comparison with that of the southeastern United States' Paleogene sequence.

Information from the previously mentioned sources is summarized in bar graphs (Figures 1-3) to illustrate faunal diversity and faunal turn-over within the various Paleogene divisions. The bar graphs in Figures 1 and 2 respectively show the number of molluscan species and genera occurring in each of the Paleogene groups of the southeastern United States. Shaded portions of the bars indicate the number of species and genera that have an earlier Paleogene occurrence. Figure 3 illustrates the faunal diversity and turn-over in the Paleocene and Eocene stages of the Paris Basin in France. Additional data on the distribution of Paleogene mollusks in the southeastern United States are given in Table 1. Data for the Claiborne Group, exclusive of the Gosport Sand, and for the Gosport Sand are included in this table as well as for the Claiborne Group as a whole. This is done for the purpose of comparing the

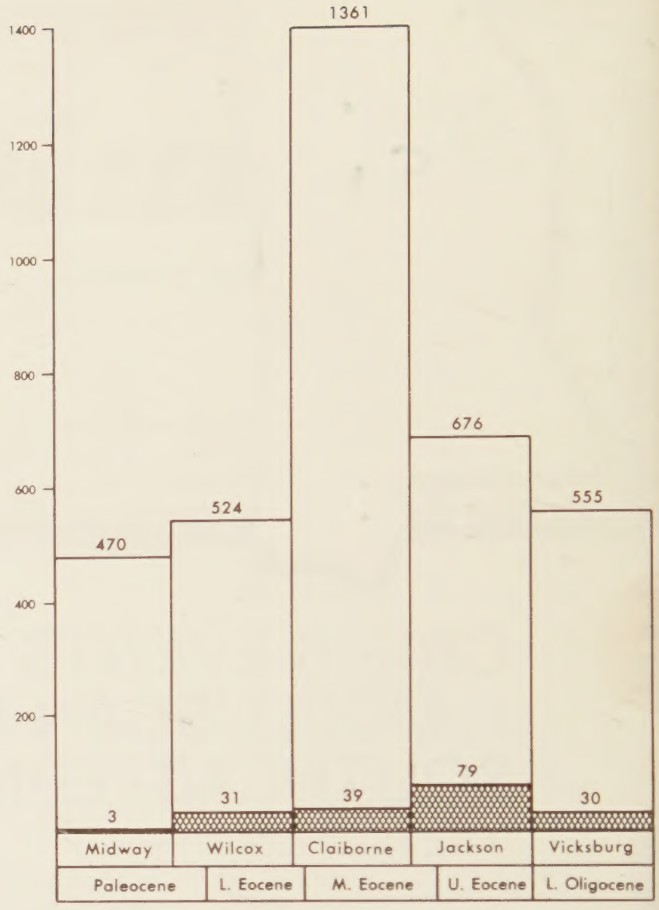

Figure 1. Number of molluscan species reported from Paleogene groups of the southeastern United States. Shaded segments indicate the number of species having an earlier occurrence.

Gosport Sand with both the Claiborne and Jackson groups. Palmer (1979) was of the opinion that the Gosport Sand represented a separate depositional cycle from that of the underlying Claiborne Group and proposed that the two be given separate stage names. Bybell (1975) and Siesser (1983) placed the Gosport Sand in the same calcareous nannoplankton zone, Martini's Zone NP17, as they did the lower unit of the Jackson Group, the Moodys Branch Formation. The molluscan data, however, indicate that the Gosport fauna is more closely related to that of the Claiborne Group than to the Jackson fauna. Of the 150 Gosport species with earlier occurrences, 145 occur in the lower units of the Claiborne Group while only 43 Gosport species continue into the Jackson Group.

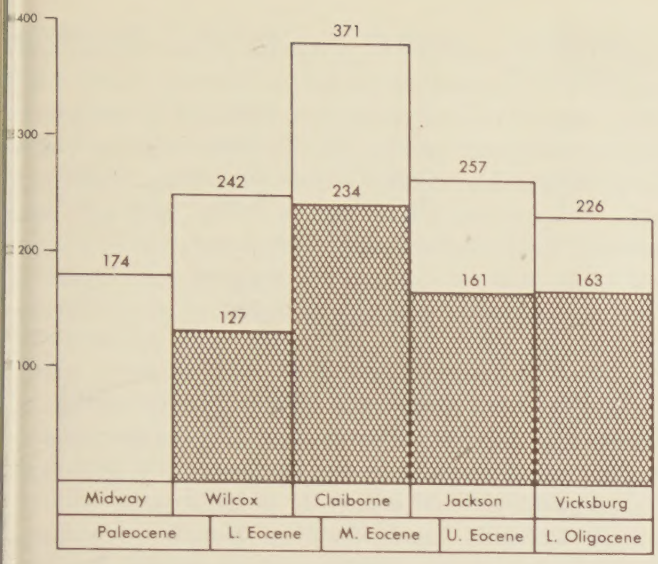

Figure 2. Number of molluscan genera reported from Paleogene groups of the southeastern United States. Shaded segments indicate the number of genera having an earlier Paleogene occurrence within the region.

INTERPRETATION OF DATA

The large scale faunal turn-overs across Paleogene group boundaries in the southeastern United States suggest major crisis events for molluscan faunas occurring at these boundaries. These turn-overs are much more prominent at the species level (Figure 1) than at the generic level (Figure 2). A steady, though slight, increase in the number of species crossing group boundaries continues into the Jackson Group and then abruptly drops off in the Vicksburg Group. Percentages of species with reported occurrences in adjacent groups are as follows: (1) 6.6% (31) of the Midway species continue into the Wilcox Group, (2) 7.1% (37) of the Wilcox species continue into the Claiborne Group, (3) 5.6% (76) of the Claiborne species continue into the Jackson Group, and (4) 3.8% (26) of the Jackson species continue into the Vicksburg Group. Based on these percentages, a downward trend in the percentage of species crossing group boundaries begins at the Claiborne-Jackson contact. However, the largest of the Paleogene crisis events occurred at the Jackson-Vicksburg contact, which corresponds to the Eocene-Oligocene boundary. Though the generic composition of the Jackson and Vicksburg faunas are similar (see Figure 2), several prominent Paleocene-Eocene genera became extinct at this boundary. These include the bivalve *Venericardia (Venericor)*, the

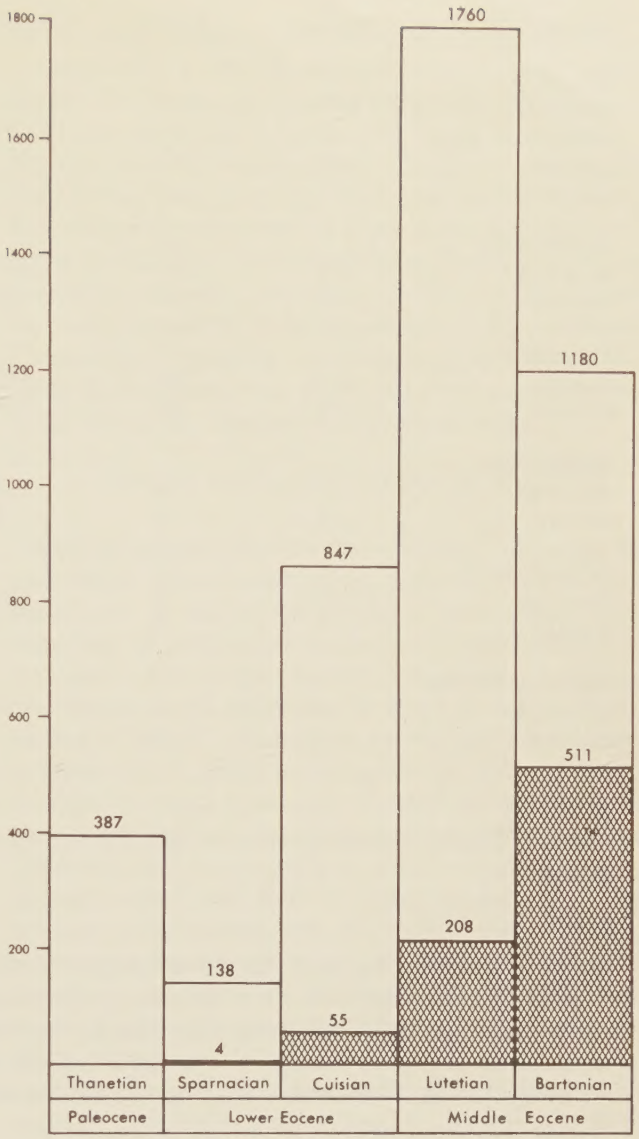

Figure 3. Number of molluscan species reported by Cossmann and Pissarro (1904-1913) from the Paleocene and Eocene of the Paris Basin in France. Shaded segments indicate the number of species having an earlier occurrence.

gastropods *Calyptraphorus, Pseudoliva, Lapparia,* and *Athleta,* and the cephalopod *Belosaepia.* Of these genera, *Venericardia (Venericor), Calyptraphorus, Pseudoliva,* and *Athleta* are important faunal elements in many early Paleogene marine units. Though not occurring in the Oligocene of North America, *Athleta* does occur in the Oligocene of the Aquitaine Basin in southern France. Based on the extinction of these taxa, which extend undiminished across earlier group boundaries, it is probable that the crisis event at the Eocene-Oligocene boundary was due in part to

GROUP	Midway	Wilcox	Claiborne	Claiborne Restricted	Gosport	Jackson	Vicksburg
MOLLUSCA							
Species	470	524	1361	975	494	676	555
Earlier Occur.	3	31	39	32	150	79	29
Genera	174	242	371	301	248	257	226
S/G Ratio	2.7	2.2	3.7	3.2	2.0	2.6	2.5
GASTROPODA							
Species	267	299	837	597	325	341	397
Genera	110	147	238	198	169	170	145
BIVALVIA							
Species	181	209	480	346	155	316	144
Genera	58	87	124	94	74	80	77
SCAPHOPODA							
Species	7	8	18	11	9	12	12
Genera	2	2	2	2	2	3	3
CEPHALOPODA							
Species	15	8	23	20	3	7	2
Genera	4	6	6	6	2	4	1
POLYPLACOPHORA							
Species	0	0	3	1	2	0	0
Genera	0	0	1	1	1	0	0

Table 1. Distribution of molluscan species and genera in Paleogene divisions of the southeastern United States.

climatic cooling as well as to changes in the depositional environment. This climatic cooling may have more strongly affected the faunas of the southeastern United States, if the continuation of *Athleta* into the Oligocene of southern France is any indication.

The Paris Basin Paleocene and Eocene sequence (Figure 3) parallels that of the southeastern United States in the continuous increase in the number of species crossing stage boundaries into the Middle Eocene. However, the much larger number of species continuing into the Middle Eocene of the Paris Basin is partly due to the reworking of faunas from older units. The Bartonian (Auversian) at Baron, France, contains sands largely derived from the Gault Formation (Albian), and the fauna includes heterochronous elements from the Cenomanian, Thanetian, Ypresian, and Lutetian (Luc Dolin, personal communication). Dolin *in* Pomerol (1980) estimated the proportion of reworked Lutetian species in the Bartonian at Baron alone to be about 5%.

The most notable correlation between the North American and Paris Basin sequences is the parallel trends in faunal diversity that have prominent peaks in the lower Middle Eocene and then a steady decline into the Oligocene. Though the number of molluscan species in the Stampian of the Paris Basin is not given, this number is significantly less than in the Bartonian. The parallel diversity trends for the broadly separated North American and Paris Basin Paleogene molluscan faunas suggests a general climatic warming into the Middle Eocene followed by progressive cooling into the Oligocene. The diversity high for Paleogene genera in the North American sequence (Figure 2) follows that for the species but lacks a prominent peak in the Claiborne Group. The species/genus ratio for the Claiborne Group is 3.7, while it varies only from 2.2 to 2.7 in other groups. This indicates that a greater provincialism due to the broad distribution of marine units in the Claiborne Group is partly responsible for the high diversity.

NATURE OF THE PALEOGENE CRISIS EVENTS

Several types of crisis events have been attributed to mass marine extinctions including: (1) periodic asteroid or comet impact, (2) climatic cooling, and (3) decrease of shelf width due to marine regression. Stanley (1984) stated that climatic cooling is the prominent cause of marine mass extinctions. He

suggested that the lowering of sea-level should have little effect on benthic marine faunas as some of the most diverse faunas occur along the west coast of the Americas and on the fringes of the Hawaiian Islands. However, a different model must be developed for a low sea-level stand in the Gulf Coast region. The stratigraphic sequence of the northern Gulf Coastal Plain shows periods of marine regression to be accompanied by deltaic development and progradation. Shelf areas down dip from major depocenters are often covered with mud units extending from the prodelta. Though these sediments carry nutrients, many molluscan species cannot tolerate the increased turbidity and increased rate of sedimentation. Parker (1956) illustrated a decrease in the diversity of molluscan faunas in shelf areas adjacent to the present Mississippi River Delta.

During various Paleogene high sea-level stands, large tracts of the Gulf Coastal Plain were covered, including the southern part of Texas, almost all of Louisiana and Mississippi, parts of the upper Mississippi Embayment in Arkansas and Tennessee, and the southern part of Alabama. Such high sea-level stands produced large inland seas extending northward from the Gulf. These inland seas and the marine transgressions preceding them affect species diversity by decreases in sedimentation rate and turbidity caused by the marine inundation of delta plains and river valleys and the formation of offshore barrier islands. These features provide traps and depositional centers for much of the fluvial sediment load so that the shelf waters maintain a low turbidity. This stable clear-water environment favors a greater faunal diversity.

The opposite conditions occur at low sea-level stands. Delta systems prograde toward the shelf edge, depositing considerable amounts of mud on the shelf and producing a high turbidity. The stability of the marine environment is further altered as these factors are seasonally controlled. If there is a slight climatic cooling during a low sea-level stand, this is amplified in the marine environment by cold arctic air masses moving southward across an increased land mass to cool a narrower marine shelf. Stanley (1984) made an important point concerning the effects of climatic cooling on marine faunas. That is, as the climate cools, the temperate species can migrate to lower latitudes, but tropical species at low latitudes have nowhere to go. This point is especially true for molluscan faunas of the Atlantic and northern Gulf coastal plains during low sea-level stands. These faunas were isolated from Caribbean land masses by the deep Gulf basin. Their only means of retreat was southward and westward toward the Mexican peninsula by means of a constricted marine shelf. For a large portion of the species accustomed to the stable, clear-water environment of a broad continental shelf, their retreat would have been blocked by prodelta mud facies extending toward the shelf edge from delta systems prograding southward from the Mississippi Embayment or from other embayments along the Gulf's northwestern flank. Extinctions at the Claiborne-Jackson boundary in the north-central Gulf were preceded by delta systems of the Cockfield Formation prograding southward toward the shelf edge across carbonate shelf and bank facies of the Cook Mountain Formation (Dockery, 1976).

ORIGIN OF SUCCESSION FAUNAS

Before the application of more refined stratigraphic correlation techniques using planktic nannofossil zonations, a model of phyletic gradualism was assumed for speciation in the Gulf Coast Paleogene sequence and large faunal turn-overs at group boundaries were attributed to gaps in the geologic record. However, calcareous nannoplankton studies of Bybell(1975, 1982) and Siesser (1983) show slight changes in flora across the Claiborne-Jackson and Jackson-Vicksburg boundaries. This indicates that these boundaries represent only a short lapse in geologic time and that the crisis events at these boundaries selectively affected benthic invertebrates. Bybell and Siesser both place the Claiborne-Jackson boundary in Martini's calcareous nannoplankton Zone NP17 and the Jackson-Vicksburg boundary in NP21.

While crises of various kinds may be called upon to explain mass extinctions in the Paleogene sequence, the sudden appearance of new and diversified faunas is a more difficult matter. The punctuated equilibrium model of speciation fits much of the distribution data for Paleogene molluscan species in the southeastern United States. In this model, stasis would continue for the major part of depositional cycles, while rapid events of speciation occur during short-term marine regressive and transgressive events associated with group boundaries.

Other factors should also be considered in the "sudden" appearance of new faunas in the North American Paleogene sequence. Species having small populations during one depositional cycle might have a population increase in the next cycle to fill gaps left by extinctions. In this case the species would only appear to have its origin above the group boundary. According to this explanation, a model of phyletic gradualism that includes a large number of provincial species having small populations could account for

much of the observed species distribution data. Another factor, which appears to be important at the Jackson-Vicksburg boundary, is the introduction of species from Europe. Though few of the Vicksburg molluscan species are conspecific with those from the Paleogene of Europe, several are extremely similar. Some of these include the bivalves *Crassatella mississippiensis* (related to *C. plumbea* — Eocene), *Crassatella lirasculpta* (related to *C. emillae* — Oligocene), and *Ventricolaria ucuttana* (related to *V. praecursor* — Oligocene), and the gastropods *Xenophora conica* (related to *X. testigera* — Oligocene to Miocene), *Sassia conradiana* (related to *S. flandrica* — Eocene to Oligocene), and *Distorsio crassidens* (related to *D. tortuosa* — Oligocene). The route taken by these species to cross the Atlantic Basin is difficult to imagine, but perhaps their larvae were transported from the Tethys Ocean by currents to the Caribbean and then into the Gulf.

CONCLUSIONS

The diversity trends for Paleogene molluscan species in the southeastern United States and the Paris Basin indicate climatic warming from the Paleocene into the lower Middle Eocene followed by cooling into the Oligocene. Both climatic cooling and marine regressions are responsible for molluscan crisis events occurring at group boundaries in the southeastern United States. The extinction of many molluscan species during marine regressions is the result of increased sedimentation and turbidity due to delta progradation and of increased seasonal temperature extremes rather than a decrease in shelf area.

ACKNOWLEDGMENTS

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CALENDAR OF EVENTS
1985 March - June

March 20-22 — Southeastern Section, Geological Society of America, meeting, Knoxville, Tennessee. (K.R. Walker, Dept. of Geological Sciences, University of Tennessee, Knoxville, TN 37996. Phone: 615/974-2366)

March 24-27 — American Association of Petroleum Geologists and Society of Economic Paleontologists and Mineralogists, annual meeting, New Orleans. (AAPG headquarters, Box 979, Tulsa, OK 74101. Phone: 918/584-2555)

April 10-12 — Forum on the Geology of Industrial Minerals, annual meeting, Tucson, Arizona. (H. Wesley Peirce, Arizona Bureau of Geology and Mineral Technology, 845 N. Park Ave., Tucson, AZ 85719. Phone: 602/621-7906)

April 12-14 — Loesses of the Lower Mississippi Valley, field trip, by Friends of the Pleistocene, South Central Cell, Baton Rouge, Louisiana. (Scott Burns, Dept. of Geosciences, Louisiana Tech University, Ruston, LA 71272. Phone: 318/257-3165)

April 14-17 — South Central Section, Geological Society of America, meeting, Fayetteville, Arkansas. (Robert C. Morris, Dept. of Geology, University of Arkansas, Fayetteville, AR 72701. Phone: 501/575-3355)

April 15-17 — Seismological Society of America, annual meeting, Austin, Texas. (Wayne D. Pennington, Institute for Geophysics, University of Texas, Box 7456, Austin, TX 78713. Phone: 512/471-3824)

April 18-21 — National Science Teachers Association, annual meeting, Cincinnati. (NSTA headquarters, 1742 Connecticut Ave. NW, Washington, D.C. 20009)

May 26-31 — American Association for the Advancement of Science, annual meeting, Los Angeles. (AAAS headquarters, 1776 Massachusetts Ave. NW, Washington, D.C. 20036. Phone: 202/467-4400)

May 27-31 — American Geophysical Union, spring meeting, Baltimore, (James W. Mercer, GeoTrans Inc., 209 Elden St., Herndon, Virginia 22070. Phone: 703/435-4400)

May 29-31 — Remote-sensed data in geographic information systems, meeting, Washington, D.C.; by NOAA, Remote Sensing Society, and Society of American Foresters. (Nancy Schiffman, S.E.S. Inc., Box 2697, Springfield, Virginia 22152. Phone: 703/644-9472)

June 16-28 — Senior executives in oil and gas industry, seminar, Vail, Colorado. (Maguire Oil and Gas Institute, Edwin L. Cox School of Business, Southern Methodist University, Dallas, TX 75275. Phone: 214/692-3151)

BOTRYOIDAL GOETHITE FROM THE CITRONELLE FORMATION (PLIOCENE-PLEISTOCENE) IN LINCOLN COUNTY, MISSISSIPPI

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INTRODUCTION

Specimens of ironstone-cemented conglomerates with botryoidal goethite [α-FeO(OH)] were recently collected from the Pliocene-Pleistocene Citronelle Formation in Lincoln County, Mississippi, by George and Tommy Covington and brought to the Mississippi Bureau of Geology for identification. These boulder-size conglomerates (Figure 1) have hollow interiors and rather thin and somewhat fragile outer shells. Paragenetically younger goethite occurs as a few millimeter-thick layer (Figures 2-4) above near amorphous multiple layers of additional iron hydroxides lining some interior regions of the conglomerates. Similar conglomerates occur frequently in the terrace gravels of the Citronelle Formation, but the occurrence of botryoidal goethite was the first seen in that formation in Mississippi by the writers. Trahan (1981) reported similar but largely microscopic layers of goethite coating grains in the pre-Loess gravels of Panola County, Mississippi (not from the Citronelle Formation as cited in the paper). The conglomerates discussed in this paper were collected from a sand and gravel pit on the west side of a road in the center of the SE/4 of Section 12, T. 8N., R. 7E., Lincoln County, Mississippi.

DESCRIPTION

The botryoidal goethite layer has a black metallic luster with some iridescence, which gives it the appearance of freshly poured tar. In cross section, the layer has a "fibrous" structure oriented normal to the layered interface. The general cementing matrix of the conglomerate is a dull, reddish-brown to black, fine-grained ironstone. This ironstone cement consists of one or more nearly amorphous iron hydroxides. Thin layers of goethite having a vitreous luster also intervene between layers of the ironstone cement, but the most significant goethite layer rests upon this cement within large voids of the conglomerates.

Three distinct ironstone layers are recognizable within the conglomerate (Figure 4). The paragenetic sequence of deposition of the iron-bearing minerals from oldest to youngest (outside to inside of the conglomerate balls) is: 1) yellow-brown to brown or gray, fractured, and blocky nearly amorphous iron hydroxide (limonitic) layer that disseminates into the voids between mineral grains. The fracturing is probably due to a desiccation phase during ironstone formation. Some of the blocky shapes are somewhat hexagonal rhombohedral forms, suggesting the possibility of pre-existing siderite that was subsequently replaced by the amorphous limonitic material. Subsequent fractures are themselves filled with a secondary, bright pale yellow iron hydroxide. 2) A middle layer, approximately a centimeter thick, of reddish-brown, nearly amorphous iron hydroxide. This layer is extremely brittle, fracture-free, and homogenous with respect to grain size. 3) The inner layer of radiating "fibers" of moderately well crystallized goethite. The "fibers" rest directly on top of layer two. The surface is glossy, botryoidal, and covered with minute ($<$1mm dia.) "bubbles" (Figure 4).

A sample from each of the three layers was ground to about 325 mesh, and examined individually by means of x-ray diffraction procedures. Goethite was confirmed as the major constituent of layer three, with perhaps a trace of hematite (Fe_2O_3). Layers two and one are largely amorphous, with a small amount of very poorly crystallized goethite. No hematite was detected in layers two or one.

Figure 1. Hollow ironstone-cemented conglomeratic boulders from the Citronelle Formation in Lincoln County, Mississippi. The rock hammer is 28 centimeters long.

Figure 2. Botryoidal goethite layer lining interior of conglomeratic boulder. Arrow points to casts of desiccation cracks. Centimeter bar for scale.

Figure 3. Botryoidal goethite layer showing "fibrous" structure in cross section. Centimeter bar for scale.

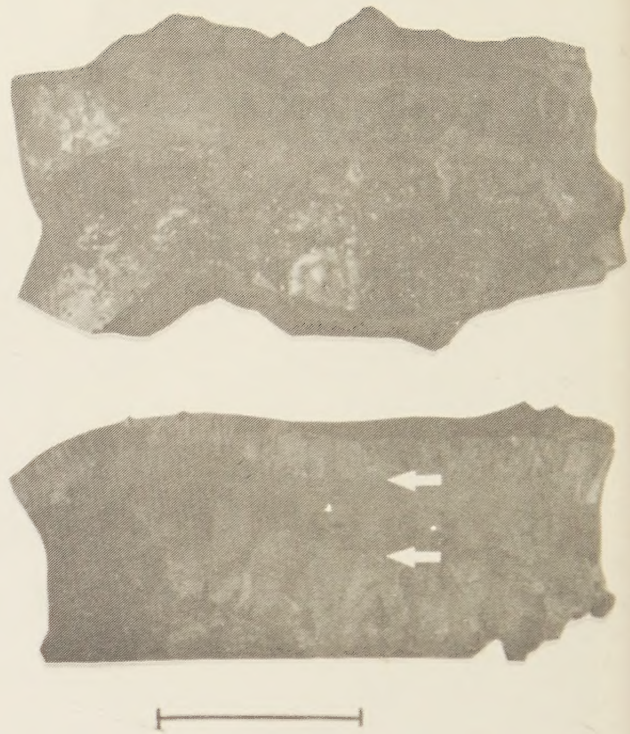

Figure 4. Cross section in lower illustration showing ironstone layers 1-3 from bottom to top (arrows indicate contacts between layers) and top illustration of minute "bubbles" on the upper surface of goethite layer. Centimeter bar for scale.

ORIGIN

The large, hollow, ironstone-cemented conglomerates of the Citronelle Formation were probably originally deposited as armored mud balls. Such mud balls formed as braided streams, in which much of the Citronelle Formation was deposited, undercut clay banks containing fine-grained sediments of the flood plain. As large blocks of clay fell into the channel, they would be enrolled in sand and gravel as they were transported downstream. Upon burial, iron oxide and/or iron hydroxide carried in solution by ground water precipitated within the porous sand and gravel armor coating of the mud balls, possibly using the impermeable mud as a nucleus for precipitation. As the land surface was rejuvenated and the water table fell, the mud interiors dried and shrank. It is probably at this time that much of the inner layer of botryoidal goethite was deposited. This botryoidal layer shows casts of desiccation cracks on some surfaces (see Figure 2). Later movement of water above the water table rewetted and disaggregated the hardened mud and removed it from the interior of the armored balls, leaving large, irregular, hollow, thin-walled, ironstone-cemented conglomerates. Precipitation of iron hydroxide continued after the mud cores of the conglomerates were evacuated. This is indicated by small goethite stalactites within some cavities.

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LOWER DEVONIAN (HELDERBERGIAN) TRILOBITES FROM THE ROSS LIMESTONE IN MISSISSIPPI

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Mississippi Bureau of Geology

INTRODUCTION

The Lower Devonian Ross Limestone is the oldest stratigraphic unit exposed at the surface in Mississippi. A low anticline brings this formation to the surface in the northeastern corner of the State at Island Hill in Pickwick Lake, Tishomingo County. At this locality carbonates of the Ross Limestone are replaced by a porous chert. This siliceous unit was named the Island Hill Formation by Morse (1930). Morse recognized a trilobite fauna in the "Island Hill Formation" and the underlying Ross Limestone, which he called the New Scotland Limestone, that consisted of the following species: (1) *Phacops logani* Hall, 1861, (2) *Dalmanites pleuroptyx* Hall, 1861, (3) *Dalmanites micrurus* Ohern, 1913, and (4) *Dalmanites stemmatus* Clarke, 1900. Two new trilobite species were named from the "Helderbergian" (Ross Limestone) of Tishomingo County by Delo (1940) as *Dalmanites mississippiensis* Delo and *Odontochile acuminatus* Ulrich and Delo.

In a recent collecting trip to Island Hill on November 28, 1984, Dockery and Merrill collected numerous trilobites from the siliceous beds of the Ross Limestone. The largest part of this collection consisted of dalmanitid pygidia. Two dalmanitid cephalons and several cephalons, pygidia, and one complete specimen of *Paciphacops (Paciphacops) birdsongensis* (Delo, 1940) were also collected.

The dalmanitid pygidia collected have 15 to 16 pleural ribs and range in size from 11 mm to 60 mm in width. These pygidia can be divided into two morphologic groups. Group one contains pygidia with a modestly convex cross section, a subtriangular outline with the posterior rounded in front of the terminal spine, and a strongly differentiated axis in which the annulations cross an axial ridge and in which the axial ridge is bordered by elongate pits located in the grooves between annulations. This group is assigned to the species *Huntonia (Huntonia) purduei purduei* (Dunbar, 1919), as are the two dalmanitid cephalons in the collection.

Group two contains pygidia with a moderately convex cross section, a triangular outline with the posterior evenly tapered in front of the terminal spine, and a largely undifferentiated axis. This group is assigned to the species *Huntonia (Huntonia) acuminatus* (Ulrich and Delo, 1940). Another species also reported from Tishomingo County, *Huntonia (Huntonia) mississippiensis* (Delo, 1940), is included in the systematic section with those previously mentioned, even though no specimens were collected.

SYSTEMATICS

Phylum ARTHROPODA
Class TRILOBITA
Order PHACOPIDA Salter, 1864
Suborder PHACOPINA Struve, 1959
Superfamily PHACOPACEA Hawle and Corda, 1847
Family PHACOPIDAE Hawle and Corda, 1847
Subfamily PHACOPINAE Hawle and Corda, 1847
Genus *PACIPHACOPS* Maksimova, 1972

Paciphacops (Paciphacops) birdsongensis (Delo, 1940)
Figures 1-2

1930. *Phacops logani* Hall, 1861. Morse, Miss. Geol. Survey, Bull. 23, p. 25, 28, 31, 40, pl. 4, fig. 3.
1940. *Phacops logani* var. *birdsongensis* Delo, Geol. Soc. Amer., Spec. Papers, no. 29, p. 19-20, pl. 1, fig. 13-15.
1973. *Phacops logani birdsongensis* Delo. Eldredge, Amer. Mus. Nat. Hist., Bull., v. 151, art. 4, p. 296-297, fig. 2A-C.
1977. *Paciphacops (Paciphacops) birdsongensis* (Delo). Campbell, Oklahoma Geol. Survey, Bull. 123, p. 52-54, pl. 9, fig. 4, pl. 11, fig. 1-2, pl. 13, fig. 5-7.

Figure 1. A complete specimen of *Paciphacops (Paciphacops) birdsongensis* (Delo, 1940) from the Ross Limestone of Island Hill, Tishomingo County, Mississippi. Centimeter bar for scale. Collected by Robert K. Merrill. MGS specimen 1476.

Distribution: Tennessee: Birdsong Shale and Ross Limestone. Mississippi: Ross Limestone.

Material Collected: One complete specimen (Figure 1) and several cephalons and pygidia.

Superfamily DALMANITACEA Vogdes, 1890
Family DALMANITIDAE Vogdes, 1890
Subfamily DALMANITINAE Vogdes, 1890
Genus *HUNTONIA* Campbell, 1977

Huntonia (Huntonia) purduei purduei (Dunbar, 1919)
Figures 3-4

1919. *Dalmanites purduei* Dunbar, Tenn. Geol. Survey, Bull. 21, p. 54.
1920. *Dalmanites purduei* Dunbar. Dunbar, Conn. Acad. Arts and Sci., Trans., v. 23, p. 148, pl. 5, fig. 1-2.
? 1930. *Dalmanites multianulatus* Ohern, 1913. Morse, Miss. Geol. Survey, Bull. 23, p. 47
? 1930. *Dalmanites stemmatus* Clarke, 1900. Morse, Miss. Geol. Survey, Bull. 23, p. 47.
1940. *Odontochile purduei* (Dunbar). Delo, Geol. Soc. Amer., Spec. Papers, no. 29, p. 62-63, pl. 6, fig. 1.
1977. *Huntonia (Huntonia) purduei purduei* (Dunbar). Campbell, Oklahoma Geol. Survey, Bull. 123, p. 93-97, pl. 19, fig. 7, pl. 24, fig. 1-7, pl. 25, fig. 1-5, pl. 30, fig. 2-3.

Distribution: Tennessee: Ross Limestone. Mississippi: Ross Limestone. Oklahoma: Haragan Marl.

Material Collected: Two cephalons (one illustrated in Figure 3) and several pygidia.

Huntonia (Huntonia) acuminatus (Ulrich and Delo, 1940)

1930. *Dalmanites pleuroptyx* Hall, 1861. Morse, Miss. Geol. Survey, Bull. 23, p. 21, 25, 28, 37, 40, 47, pl. 4, fig. 1.
? 1930. *Dalmanites micrurus* Clarke, 1908. Morse, Miss. Geol. Survey, Bull. 23, p. 47.
1940. *Odontochile acuminatus* Ulrich and Delo *in* Delo, Geol. Soc. Amer., Spec. Papers, no. 29, p. 55, pl. 5, fig. 9-10.

Figure 2. Three cephalons of *Paciphacops (Paciphacops) birdsongensis* (Delo, 1940) from the Ross Limestone at Island Hill, Tishomingo County, Mississippi. Centimeter bar for scale. Collected by David T. Dockery. MGS specimen 1477.

1977. ? *Huntonia (Huntonia) purduei purduei* (Dunbar, 1919). Campbell, Oklahoma Geol. Survey, Bull. 123, p. 93-95.

Distribution: Mississippi: Ross Limestone. Oklahoma: Haragan Marl.

Material Collected: Several pygidia.

Huntonia (Huntonia) mississippiensis (Delo, 1940).

1940. *Dalmanites mississippiensis* Delo, Geol. Soc. Amer., Spec. Papers, no. 29, p. 47-48, pl. 3, fig. 31.

1977. *Huntonia (Huntonia) mississippiensis* (Delo). Campbell, Oklahoma Geol. Survey, Bull. 123, p. 95.

Distribution: Mississippi: Ross Limestone.

Material Collected: None.

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Figure 3. Cephalon of *Huntonia (Huntonia) purduei purduei* (Dunbar, 1919) from the Ross Limestone at Island Hill, Tishomingo County, Mississippi. Centimeter bar for scale. Collected by David T. Dockery. MGS specimen 1478.

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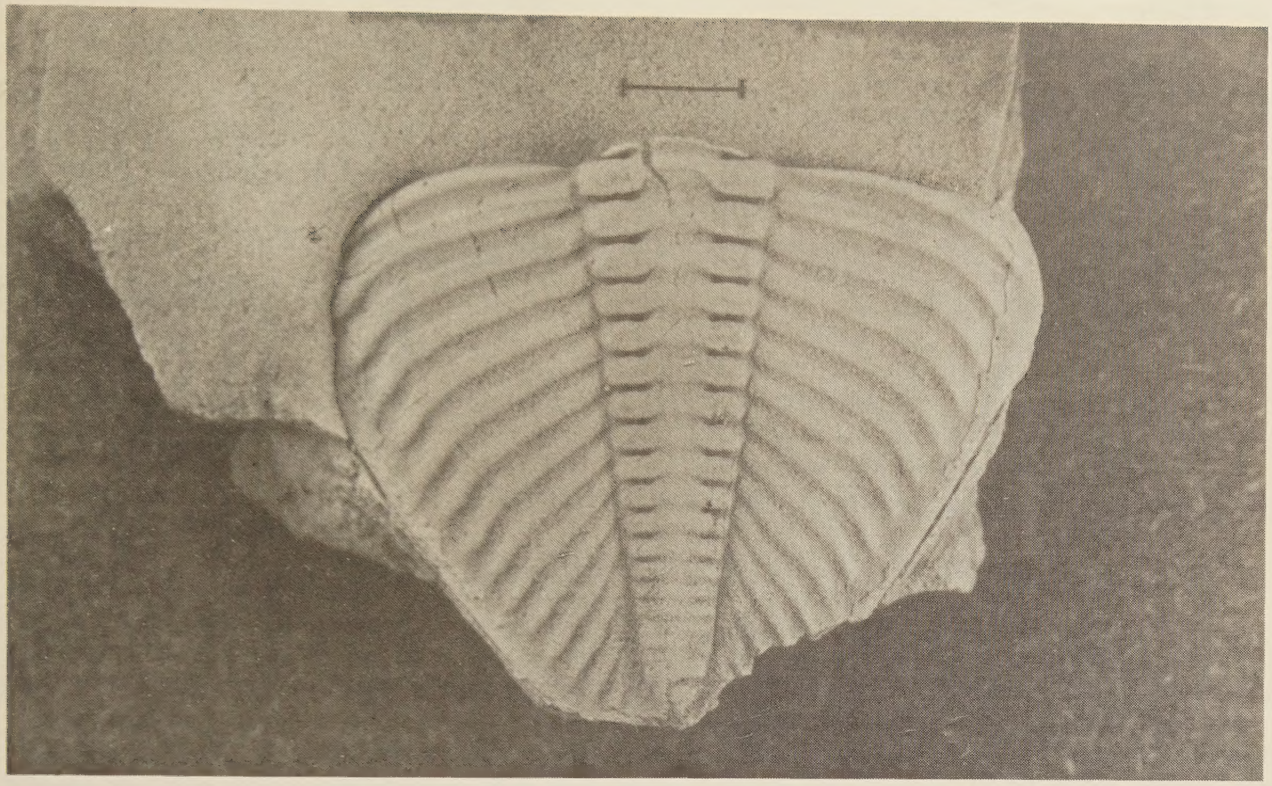
Ohern, D.W., *in* Ohern, D.W., and T.P. Maynard, 1913, Systematic paleontology, Lower Devonian. Trilobita: Lower Devonian: Maryland Geological Survey, p. 489-512, pl. 89-94.



igure 4. Pygidium of *Huntonia (Huntonia) purduei purduei* (Dunbar, 1919) from the Ross Limestone at Island lill, Tishomingo County, Mississippi. Centimeter bar for scale. Collected by David T. Dockery. MGS specimen 479.

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